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A Low-Cost Technique for Increasing Pine Volume Production in Mixed Pine-Hardwood Stands

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SUMMARY

Overtopping hardwoods were cut in 1939 at three levels of intensity to release natural pine seedlings that had become established in a mixed pine-hardwood stand. Pines and hardwoods were periodically harvested between 1939 and 1965 by using selection cutting of individual trees. After 47 years, the two most intensive release treatments had produced more cubic-foot pine volumes and had higher benefit-cost ratios than the least intensive treatment. There were no differences among treatments in hardwood production. Modest investments for pine release offer private nonindustrial landowners a low-cost technique for managing properties containing mixed pine-hardwood stands.

A Low-Cost Technique for Increasing Pine Volume Production in Mixed Pine-Hardwood Stands

Michael D. Cain

INTRODUCTION

Private nonindustrial forest landowners (PNIFL) control over 70 percent of the forest land in the South. These individuals have a variety of reasons for woodland ownership that include aesthetics, recreation wildlife, private retreat, firewood, and timber production. Many of these interests can best be realized from mixed pine-hardwood stands rather than from pure pine or pure hardwood stands.

On most upland sites throughout the South, pine species grow better than hardwood species, are in greater demand by the forest industry, and usually bring the best price to landowners. It is not uncommon for well-managed, uneven-aged loblolly (*Pinus taeda* L.)-shortleaf (*P. echinata* Mill.) pine stands to produce 400 to 500 board feet (Doyle) of sawtimber or 1 to 1.5 cords of pulpwood per acre annually (Grano 1967). However, according to Young and others (1985), if assistance programs assume that timber production is the major goal of most nonindustrial forest owners, those programs will most likely fail. Therefore, because of the varied interests of the large PNIFL population, foresters should consider recommending to them low-cost management alternatives that have the potential for increasing wood production while perpetuating mixed pine-hardwood stands.

In 1939 a study was established in a 16-acre area on the Crossett Experimental Forest in southern Arkansas to determine if suppressed pine seedlings would respond to release from a pine-hardwood overstory (Mann 1951). This paper reports the growth gains for the merchantable pine and hardwood components over a period of 47 years. An 80-acre unmanaged pine-hardwood stand, located 1 mile from the release study, provided a growth comparison over a 46-year period.

METHODS

Study Area

The soil on the pine release study area is Bude (Glossaquic Fragiudalf) silt loam, and soils on the comparison stand are Bude, Providence (Typic Fragiudalf), and Arkabutla (Aeric Fluvaquent) silt loams (USDA 1979). Bude and Providence soils were formed in thin loessial deposits and have an impervious layer at 18 to 40 inches that impedes internal drainage. Arkabutla soil formed in silty alluvium and is subject to flooding in late winter and early spring.

The site index for all these soils is 85 to 90 feet for loblolly pine at base age of 50 years. Annual precipitation averages 55 inches, with extremes of wet winters and dry autumns. Elevation is about 175 feet, and topography is nearly level.

Management History and Treatment

In 1939 both areas were part of the typical loblolly-shortleaf, pine-hardwood forest that developed following a diameter-limit cut to 12 inches d.b.h. in 1915. With the exception of fire protection and occasional cut-and-leave or salvage from small bark beetle infestations, no management practices have been undertaken in the unmanaged stand since 1937.

In the unmanaged stand at the time of the first inventory (1937), pine density averaged 90 trees per acre in the 4- to 9-inch d.b.h. classes and 40 trees per acre that were 9 inches d.b.h. and larger. There were 41 merchantable-size hardwoods per acre that ranged from 5 to 37 inches d.b.h. No inventory was made of the submerchantable pine or hardwood component until 1954.

The pine release area had the following stand characteristics. About 22 pines per acre were 9 inches d.b.h. and larger, and about 53 pines per acre ranged from 4 to 9 inches d.b.h. Pines less than 4 inches d.b.h. had a density of 1,400 trees per acre, of which 1,200 per acre were pine seedlings originating from a good seed crop in 1935. The hardwood component included 300 trees per acre that ranged from 2 to 20 inches d.b.h., and about 6,000 stems per acre in small trees and shrubs that were less than 2 inches d.b.h.

Three intensities of pine release were initially tested:

Treatment 1—Remove hardwoods 6 inches d.b.h. and larger (overstory hardwoods).

Treatment 2—Remove hardwoods 2 inches d.b.h. and larger (midstory and overstory hardwoods).

Treatment 3—Remove hardwoods that were taller than 5 feet (midstory, overstory, and some understory hardwoods).

Hardwoods were removed by cutting, but only if their crowns were overtopping or were within 2 feet of overtopping the terminal leader of a pine. Each treatment was replicated four times in a randomized complete block design. All 12 plots were at least 1.25 acres in size.

Harvesting of merchantable pines and hardwoods was done using the single tree selection system in 1939 and 1949. In 1955, two replications of each release treatment were subdivided to form 0.5-acre plots for demonstration purposes, and the main study was closed. At that time, pine release treatments were repeated using the herbicide 2,4,5-T, but only on the six 0.5-acre demonstration plots as follows:

Treatment 1—Treat all hardwoods 4 inches d.b.h. and larger.

Treatment 2—Treat all hardwoods 2 inches d.b.h. and larger.

Treatment 3—Treat all hardwoods that either overtopped or had their crowns interlocked with those of pines.

In these three treatments, hardwoods 4 inches d.b.h. and larger were frilled and treated with a 1-percent aqueous solution of 2,4,5-T. Hardwoods 3 inches d.b.h. and smaller were cut and their stumps treated with a 5-percent solution of 2,4,5-T in diesel oil. Labor and material costs for the release treatments were recorded in 1939 and 1955.

Additional harvesting of pines and hardwoods was done on the 0.5-acre demonstration plots in 1955, 1960, and 1965 when management ceased. The only silvicultural treatment to be applied since 1965 was a prescribed burn over the entire 16-acre study area in March 1980 for fuel hazard reduction.

Measurements and Data Analysis

Before release treatments in 1939, all pines and

hardwoods of merchantable size (≥ 3.6 inches d.b.h.) were inventoried by 1-inch d.b.h. classes on a plot-by-plot basis. Hardwoods were categorized by red oak, white oak, gum, and others. A similar inventory of all merchantable-size trees was conducted on the 80-acre unmanaged stand in 1937.

Records of trees harvested in the release study were kept by species groups and number of trees cut by 1-inch d.b.h. classes. The submerchantable pine and hardwood component in the release study was inventoried in 1939 by using a 5-percent strip cruise through the center of each plot.

In addition to plot summaries, 80 pine seedlings on plots that received the most intensive release (treatment 3) were numbered, mapped, and their height and d.b.h. measured periodically from 1939 through 1954 to obtain data on individual tree growth and survival. Remeasurement of survivors from these 80 trees was made in 1980.

In the spring of 1986, boundaries of the original 12 release plots were reestablished, and all merchantable pines and hardwoods were inventoried by 1-inch d.b.h. classes and species' groups. A comparable inventory was made in the 80-acre unmanaged stand in 1983. Pine volumes were determined from loblolly-shortleaf volume equations (Farrar and others 1984). Hardwood volumes were obtained from a hardwood volume table for the Crossett Experimental Forest (Reynolds 1959). Volume production was determined as follows:

Residual volume + cut volume - initial volume = volume production.

In the release study, analysis of variance was used to evaluate treatment differences for pine and hardwood growth. Duncan's multiple range test was used to partition mean differences among treatments. All analyses were conducted at the 0.05 level of significance. Percentage values were compared using the arcsin transformation.

For the financial evaluation, annual production in the unmanaged stand was subtracted from annual production in each of the pine release treatments to provide a measure of pine growth response and returns from release. Principal compound interest formulas (Davis 1966) were used with historical product values, historical treatment costs, and a 5-percent interest rate.

RESULTS AND DISCUSSION

The First 15 Years After Pine Release

The 1939 posttreatment inventory showed that treatments 1, 2, and 3, respectively, released 47, 571, and 695 pine seedlings per acre (table 1). Treatment 1 was considered to be ineffective because only 5 percent of overtopped seedlings were released as compared to about 50 percent in treatments 2 and 3. Most of the pine

Table 1.—Treatment effectiveness for increasing the number of released pine seedlings

Treatment	Mean pine seedling density				Proportion of overtopped seedlings released
	Before release		After release		
	Total	Overtopped	Released	Free to grow	
	Stems/acre				
1	1,381	1,007	4	421	3
2	1,185	1,913	571	743	86
3	1,534	1,421	695	808	89

seedlings that were not released by treatments 2 and 3 were overtopped by either pine seed trees or advanced pine regeneration. Also, additional pine seedlings in each treatment were already free-to-grow and required no release. Mean density of these seedlings was 374 per acre, 172 per acre, and 113 per acre for treatments 1, 2, and 3, respectively. Thus, at the beginning of the growth cycle following the 1939 release treatments, the number of pine seedlings free-to-grow averaged 421 per acre in treatment 1, 743 per acre in treatment 2, and 808 per acre in treatment 3 (table 1). All of these densities provide adequate stocking of seedlings in uneven-aged pine management (Cain and others 1987).

Historical records for natural pine seeding on the Crossett Experimental Forest during the 15-year study

indicate that good seed crops occurred in 1939, 1942, 1947, and 1951. The reduction of overtopping hardwoods and the release of established pine seedlings in 1939, plus the ingrowth of pines from subsequent seed crops, resulted in dense patches of advanced natural pine regeneration on many study plots by 1950. That sequence of events is illustrated in figures 1, 2, and 3 for a plot in treatment 3.

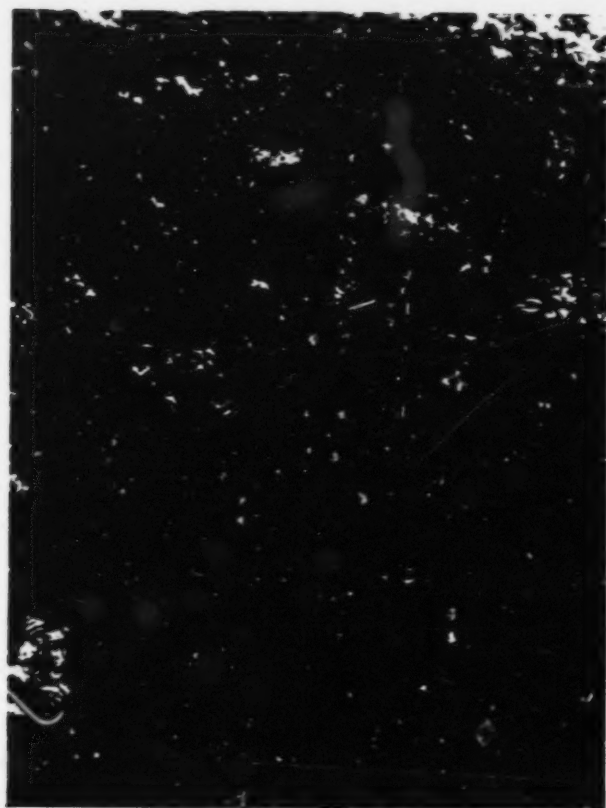
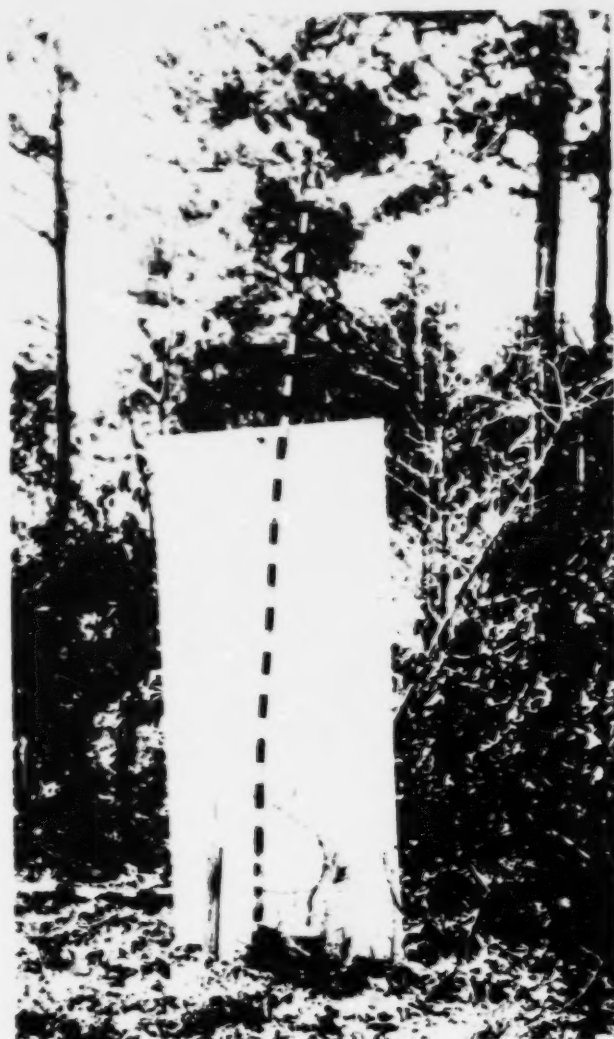


Figure 1.—Mixed pine-hardwood stand in June 1937, before pine release.



Figure 2.—Same view as figure 1 in May 1940, after cutting overtopping hardwoods taller than 5 feet (treatment 3).



The first of the two photographs shows a dense forest of tall, thin trees, likely birches, with a path or clearing in the foreground. The second photograph shows a white rectangular marker with a vertical dashed line, standing in a wooded area.

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Figure 5.—Same view as figure 4 in May 1943. In just 3 years, a red oak (*Quercus /alcata* Michx.) stump sprout had overtopped the pine seedling.

twice as great as those overtopped by pines and four times as great as those overtopped by hardwoods or pine-hardwood.

A reassessment of overtopping conditions was made in 1954. For pines less than 7 inches d.b.h., 40 percent were overtopped by hardwoods in treatment 1, 24 percent in treatment 2, and 20 percent in treatment 3. At that time, hardwood density averaged over 3,000 stems per acre for trees less than 2 inches d.b.h. and 500 stems per acre for larger trees. There was very little difference in hardwood density among treatments.

Growth Response 47 Years After Pine Release

Merchantable-Size Pines.—Forty-six or 47 years after pine release, substantially more pines were produced on the release plots (89 to 189 trees per acre) than in the unmanaged stand (25 trees per acre) where no release had been done (fig. 6). In the release study, the two most intensive treatments (2 and 3) averaged about 100 more pines per acre than treatment 1 (fig. 6 and table 2). Most pines less than 15 inches d.b.h. that were produced on

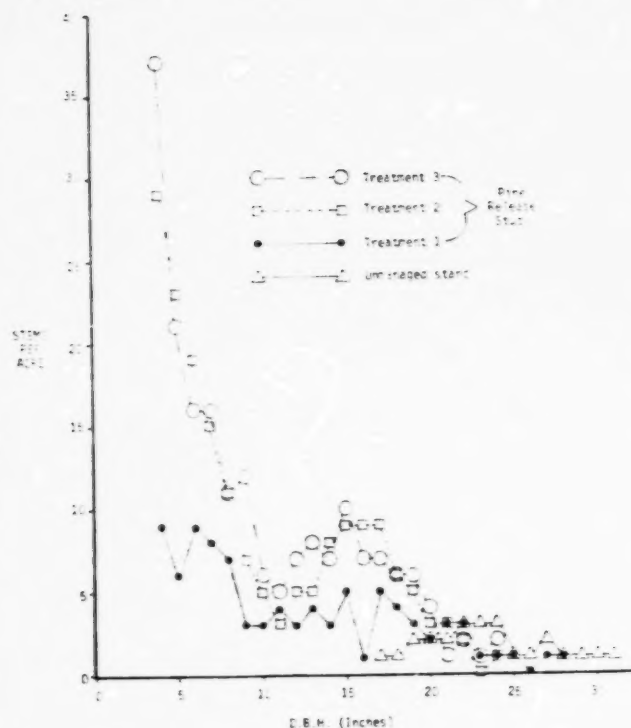


Figure 6.—Production of pine stems by diameter class for the release study (47 years) and the unmanaged stand (46 years). Production by diameter class = Residual pine density in 1986 + pines harvested from 1939 to 1965 - initial pine density in 1939.

the release plots (fig. 6) were ingrowth as a result of varying intensities of pine release and improvement cuts between 1939 and 1965.

Annual basal area growth and cubic-foot volume growth were significantly improved by cutting mid-story and overstory hardwoods 2 inches d.b.h. and larger as compared to removing only overstory hardwoods that were 6 inches d.b.h. and larger (table 2). Cutting of hardwoods down to 5 feet tall resulted in no

Table 2.—Merchantable pine production in density, basal area, and volume during 47 years by intensity of release¹

Treatment	Density	Mean growth/acre-year			
		Basal area	Volume		
			Pulpwood	Sawlog	Total merchantable
	Stems/acre	ft ² /acre	ft ³ /acre	ft ³ /acre	ft ³ /acre
1	89a	1.9a	11a	45a	56a
2	176ab	2.6 b	19 b	56 b	75 b
3	189 b	2.7 b	21 b	57 b	77 b
Error mean square	3,033	0.1	21	28	45

¹Production = Residual + cut - initial. Within-column means followed by the same letter are not significantly different at the 0.05 level.

²Pulpwood = Cubic feet roundwood from trees 3.6 to 9.5 inches d.b.h. + cubic feet topwood from trees greater than 9.5 inches d.b.h.

Table 3.—Mean stand variables in 1986 for merchantable-size pines by the intensity of release¹

Treatment ²	Density	Basal area	Volume per acre		Proportion of pine to total density
			Pulpwood	Sawlog	
	Stems/ac	Ft ² /ac	Ft		Percent
1	58a	73a	401a	1,847a	29a
2	73 b	94 b	529 b	2,370 b	34ab
3	82 b	95 b	574 b	2,295 b	38 b
Error mean square	51	61	3,176	47,435	7

¹Within-column means followed by the same letter are not significantly different at the 0.05 level.

²Pulpwood = Cubic feet roundwood from trees 3.6 to 9.5 inches d.b.h. + cubic feet topwood from trees greater than 9.5 inches d.b.h.

additional growth gains for pines during the 47-year interval. Although pine pulpwood and sawlog volumes were significantly improved by more intensive release from overtopping hardwoods in this study, the higher rates of annual cubic-foot production in treatments 2 and 3 were only about two-thirds of the potential for well-stocked, uneven-aged stands of loblolly-shortleaf pines where there has been intensive hardwood control at periodic intervals (Reynolds and others 1984).

Differences among release treatments for the residual merchantable pine stand in 1986 were comparable to those for total production during the 47-year interval. The two most intensive treatments had significantly higher pine densities, more pine basal area, and greater merchantable cubic-foot volumes than treatment 1 (table 3).

The most intensive release (treatment 3) resulted in a significantly higher percentage of merchantable-size pines to hardwoods (38 percent) in 1986 as compared to the least intensive release (treatment 1) (29 percent). When measurements were taken in 1986, there had been no management of consequence for over 20 years, which contributed to hardwood dominance in stems per acre. Similar trends in other long-term investigations of silvicultural treatments suggest that nonmanagement is a predisposing factor to hardwood invasion and to ultimate dominance by hardwood species on pine sites of the Upper Coastal Plain (Cain and Yaussy 1983, 1984, Cain 1985).

Of the 80 individual pine seedlings numbered and mapped in 1939 for remeasurement, 40 had either died or had been harvested by 1954 when the release study closed. Only 9 of the remaining 40 could be located in 1980, when remeasurements were taken. At the time of release, 54 percent of the original 80 seedlings were less than 3 feet tall and 46 percent ranged from 3 to 7 feet tall.

Eight of the nine surviving pine seedlings were taller than 3 feet in 1939. When released, average height of the nine survivors was 4.5 feet, ranging from 2 to 6 feet. Although the fate of the missing 71 pines is unclear,

data from the nine survivors suggest that a single treatment to release pine seedlings from overtopping hardwoods by cutting may not be sufficient for pines less than 3 feet tall because of the rapid growth of hardwood sprouts or because of competition from uncut residuals.

An assessment of overtopping condition for the nine surviving pines in the present study was made in 1954, 15 years after release. At that time seven of the nine pine seedlings were growing in the open and two were overtopped by pine only. It should be emphasized that none of the nine surviving pines were overtopped by hardwoods. Diameter (d.b.h.) growth of the nine survivors between 1954 and 1980 averaged 0.31 inch per year, which is the expected rate of growth for loblolly-shortleaf pines in uneven-aged stands (Reynolds and others 1984). The rate of height growth for survivors averaged 2.0 feet per year from 1939 to 1980.

Merchantable-Size Hardwoods.—One might infer that merchantable hardwood production in the pine release study was inversely related to merchantable pine production by the degree of release. There were, however, no statistically significant differences among treatments for mean hardwood density, annual basal area growth, or annual cubic-foot growth per acre during the 47-year interval (table 4).

Compared to pines, many more hardwoods were

Table 4.—Merchantable hardwood production in density, basal area, and volume during 47 years by intensity of release¹

Treatment	Density	Mean growth/acre-year	
		Basal area	Merchantable Volume
	Stems/ac	Ft ²	Ft ³
1	173a	1.2a	22a
2	230a	1.1a	20a
3	229a	1.2a	21a
Error mean square	1,177	0.04	15

¹Production = Residual + cut - initial. Within-column means followed by the same letter are not significantly different at the 0.05 level.

produced per acre. Nevertheless, annual cubic-foot volume production for pines was more than twice as great as annual cubic-foot growth for hardwoods, regardless of the intensity of release.

In 1986, residual hardwood density, basal area, and cubic-foot volumes tended to average higher in treatment 1, where hardwood control had been less intensive (table 5). Even so, differences among treatment means for residual hardwoods were statistically nonsignificant.

Table 5.—Mean stand variables in 1986 for merchantable-size hardwoods by intensity of release¹

Treatment	Density	Basal area	Volume per acre	
			Sawlog	Total merchantable
	Stems ac	Ft ² ac	Fl	Fl
1	144a	42a	351a	743a
2	144a	35a	228a	615a
3	132a	33a	227a	572a
Error mean square	546	75	1.2732x10 ⁴	2.4581x10 ⁴

¹Within-column means followed by the same letter are not significantly different at the 0.05 level.

Lack of significant differences in hardwood production among release treatments in this study demonstrates the ability of hardwood species to come back following varying degrees of control. Even more intensive treatments for eradicating hardwoods have been followed by their reinvasion on pine sites (Cain and Yaussy 1984). Such resilience provides landowners with an opportunity to manage their forest property for both pines and hardwoods if their objective is development of mixed stands.

Merchantable hardwoods in 1986 were predominantly oak species in treatments 1 and 2 but gum species in treatment 3 (table 6). Volume of oaks in 1986 was significantly higher in treatment 1 (466 cubic feet per acre) compared to treatment 3 (272 cubic feet per acre); and treatment 2 (349 cubic feet per acre) fell between those extremes. For the other hardwood groups, there were no differences in mean residual volumes among release treatments.

Valuation of Release Treatments

Since treatments in 1939 and 1955 were specifically for pine release, only pine products were used in this evaluation. In the unmanaged stand over a 46-year period, annual sawlog production averaged 45 cubic feet per acre, and annual pulpwood production averaged -5.8 cubic feet per acre or -0.08 cord per acre. Lack of ingrowth from natural pine regeneration and the movement of pulpwood-size pines into sawlog-size

pinus resulted in reductions in cubic-foot volume or negative cubic-foot growth of the pulpwood component in the unmanaged stand. These production figures were subtracted from pine pulpwood and sawlog growth in each of the release treatments (table 7). Cost was based on historical records for hours utilized in supervision and labor for hardwood removal, as well as the amount of herbicide and oils used for injection or stump treatment.

Table 6.—Proportion of merchantable hardwoods by species group in 1986

Hardwood species group	Release treatment		
	1	2	3
	Percent		
Red oaks ¹	20	25	17
White oaks ²	27	19	17
Gum ³	33	35	39
Others	20	21	27
Total	100	100	100

¹Principally: *Quercus talcala* Michx., *Q. nigra* L., and *Q. phellos* L.

²*Q. alba* L., and *Q. stellata* Wangenh.

³*Liquidambar styraciflua* L., and *Nyssa sylvatica* Marsh.

The resulting benefit/cost ratios were similar for treatments 2 and 3, where pines were released from overtopping hardwoods that were 2 inches d.b.h. and larger. Cutting overtopping hardwoods taller than 5 feet (treatment 3) was the most intensive treatment for pine release, but costs were somewhat higher and long-term volume gains were no better than those attained in treatment 2. The historical costs incurred in this study for release of natural pine regeneration from overtopping hardwoods were minimal. Even at current prices, the cost of pine release is some \$30 to \$40 per acre less than average per-acre cost reported for intensive site preparation preceding pine plantation establishment on Southern Coastal Plain sites (Watson and others 1987).

After 47 years, cubic-foot volume production for pine in treatment 1 was significantly less than that achieved in treatments 2 or 3 and was not much better than pine growth in the unmanaged stand. Since release treatments were applied only once (1939), with partial repetition in 1955, long-term results for pine production tend to favor more intensive release (treatments 2 and 3) over less intensive release (treatment 1). Yet, compared to the diameter distribution in the unmanaged stand, treatment 1 resulted in substantial pine ingrowth gains for the smaller size classes (fig. 6). Therefore, if overtopping hardwoods 6 inches d.b.h. and larger were cut at more frequent intervals than was done in this study, such as periodically for firewood, costs for pine release could be minimized while maximizing benefits to the landowner.

Table 7.—Long-term economic benefits from three intensities of pine release

Treatment	Increased pine production ¹		Cost of pine release ²	Net return from pine release ³	Net return relative to unmanaged stand ³	Benefit cost Ratio
	Pulpwood	Sawlog				
	Cords ac yr	Fmb ac yr		Dollars ac yr		
1	0.22	0	1.67	37.02	0	0
2	0.33	64	1.99	42.23	2.93	1.5
3	0.36	69	2.25	43.01	3.71	1.6

¹ Difference between production from pine release plots and the unmanaged stand.² Historical costs of pine release in 1939 and 1955, compounded at 5% to present (1987).³ Historical product values compounded at 5% to present, less treatment cost.⁴ Difference between net return from the pine release and present value of \$15/cord and \$150/fbm for pine production in the unmanaged stand.Doyle scale converted from cubic feet (172 ft³ Mbd ft).

MANAGEMENT RECOMMENDATIONS

Low-cost silvicultural techniques are needed for managing private nonindustrial forest lands. In this study, natural loblolly-shortleaf pine seedlings were released in 1939 by cutting overtopping hardwoods in a mixed pine-hardwood stand. Three intensities of pine release resulted in substantially better diameter distributions for pine over a 47-year interval when compared to an unmanaged pine-hardwood stand where no treatments were imposed. The two most intensive release treatments (removal of midstory and overstory hardwoods and removal of midstory, overstory, and some understory hardwoods) also significantly increased long-term, cubic-foot volume production of pines as compared to plots where only overstory hardwoods were removed.

For individual pine seedlings released in 1939, growth and development during the next 15 years was best where seedlings remained free-to-grow. The cost of releasing natural pine regeneration was minimal compared to intensive site preparation used to establish pine plantations. Because of the degree of hardwood reinvasion and the high mortality of individual pine seedlings in the first 15 years, a second release is recommended within 3 years of the first treatment if pine seedlings are less than 3 feet tall. In addition, periodic thinnings of the overstory pines and hardwoods would be needed to accelerate growth of the understory pine component. Such thinnings should be done with the intent of upgrading the quality of the residual stand.

To reduce sprouting, hardwoods should be controlled with herbicides. McGee (1986) reported that when residual hardwoods were injected with a herbicide following a shear-felling operation, over 60 percent of planted loblolly pines were free-to-grow 5 years later, but only about 30 percent of planted pines were free-to-grow 5 years later without the herbicide treatment of residual hardwoods. Similarly, Miller and Phillips (1984) studied the effects of shearing and chain-saw cutting on stump-sprout regeneration of hardwoods. They found that

hardwood stumps treated with herbicides had fewer sprouts compared to untreated stumps.

Because of the propensity of hardwoods to sprout following cutting, growth and development of the hardwood component in the present study did not differ significantly among the release treatments during the 47-year period. That can be an important asset for landowners who desire to manage their stands for both pines and hardwoods. Although many hardwood species have desirable attributes from aesthetic and wildlife points of view, some hardwoods are not as valuable as others for utilization. For example, if a landowner's objective is firewood production, oak species would be more desirable than gum species. In that case, pine release from desirable oak species could be done by cutting to stimulate oak sprouting and pine growth. Whereas pine release from a less desirable firewood species, like blackgum, could be done using a herbicide injection to reduce or eliminate sprouts.

For landowners who wish to maximize periodic income from timber production on their properties, consideration should be given to managing uneven-aged stands of pure pine. With intensive hardwood control, pine volume production can be doubled when compared to that attained in this mixed pine-hardwood stand.

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CAUTION: Fungicides and pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all fungicides and pesticides selectively and carefully. Follow recommended practices for the disposal of surplus fungicides, pesticides, and their containers.

Cain, Michael D. 1988. A low-cost technique for increasing pine volume production in mixed pine-hardwood stands. Res. Pap. SO-246. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 9 p.

Study examines long-term volume production in a natural, uneven-aged, pine-hardwood stand in southern Arkansas, 47 years after three intensities of pine release. Volume and cost data were evaluated relative to production from an unmanaged stand during a comparable time interval.

Additional keywords: *Pinus echinata* Mill.; *P. taeda* L.; natural regeneration; pine release; uneven-aged management.